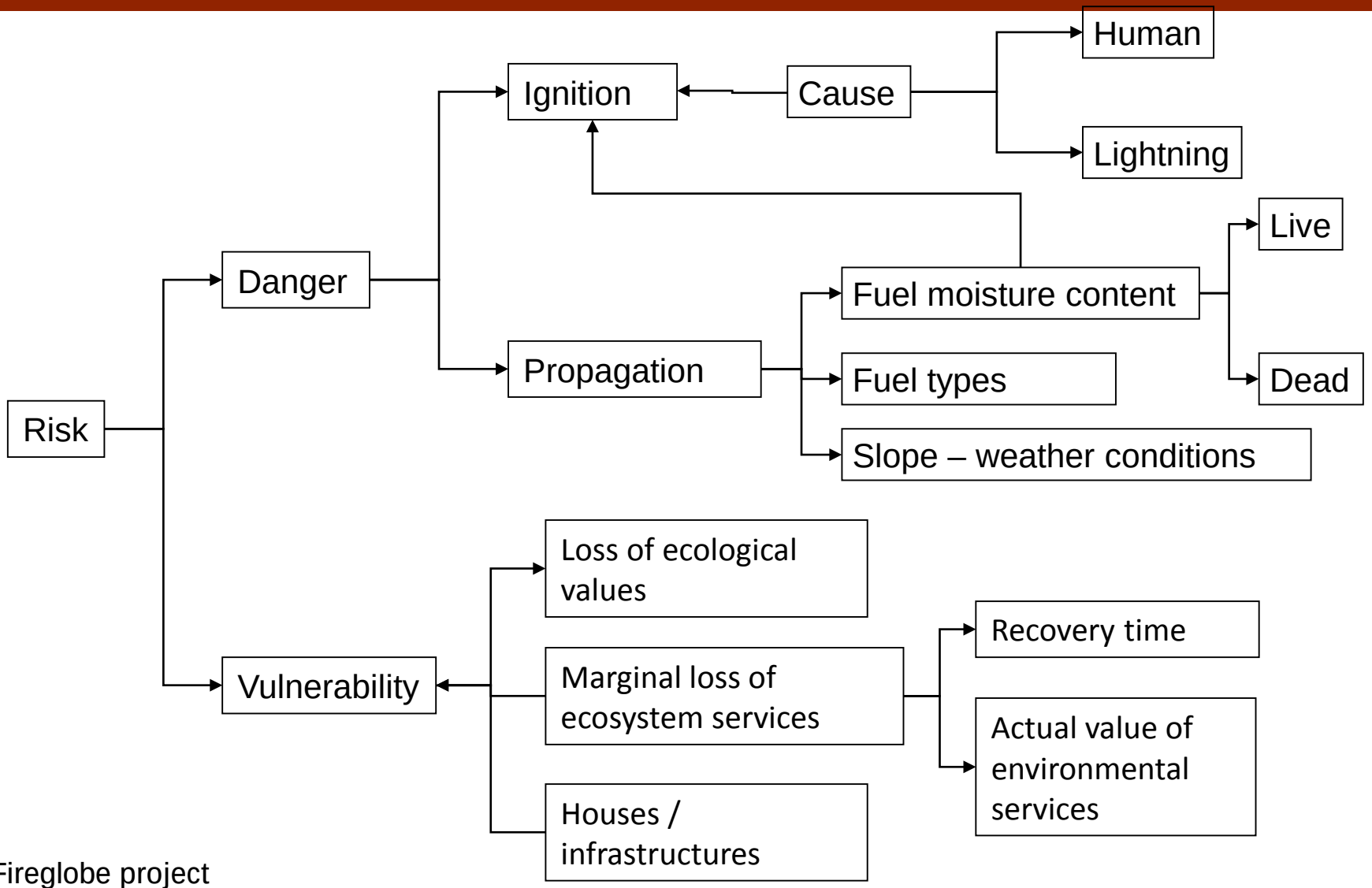
Global analysis of vulnerability

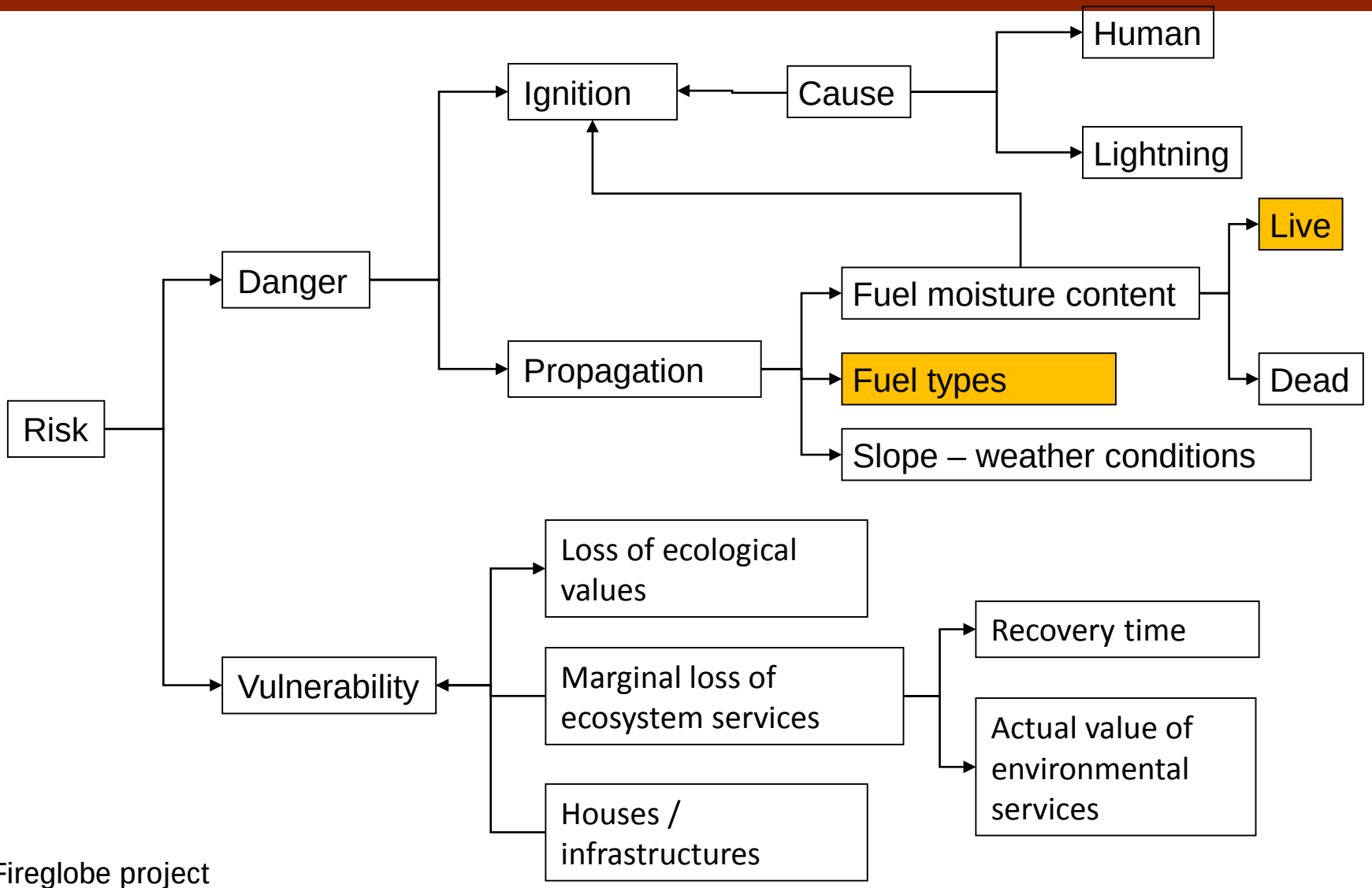
Emilio Chuvieco
Environmental Remote Sensing Research Group
University of Alcalá, Spain
emilio.chuvieco@uah.es

Fire risk = Danger * Vulnerability



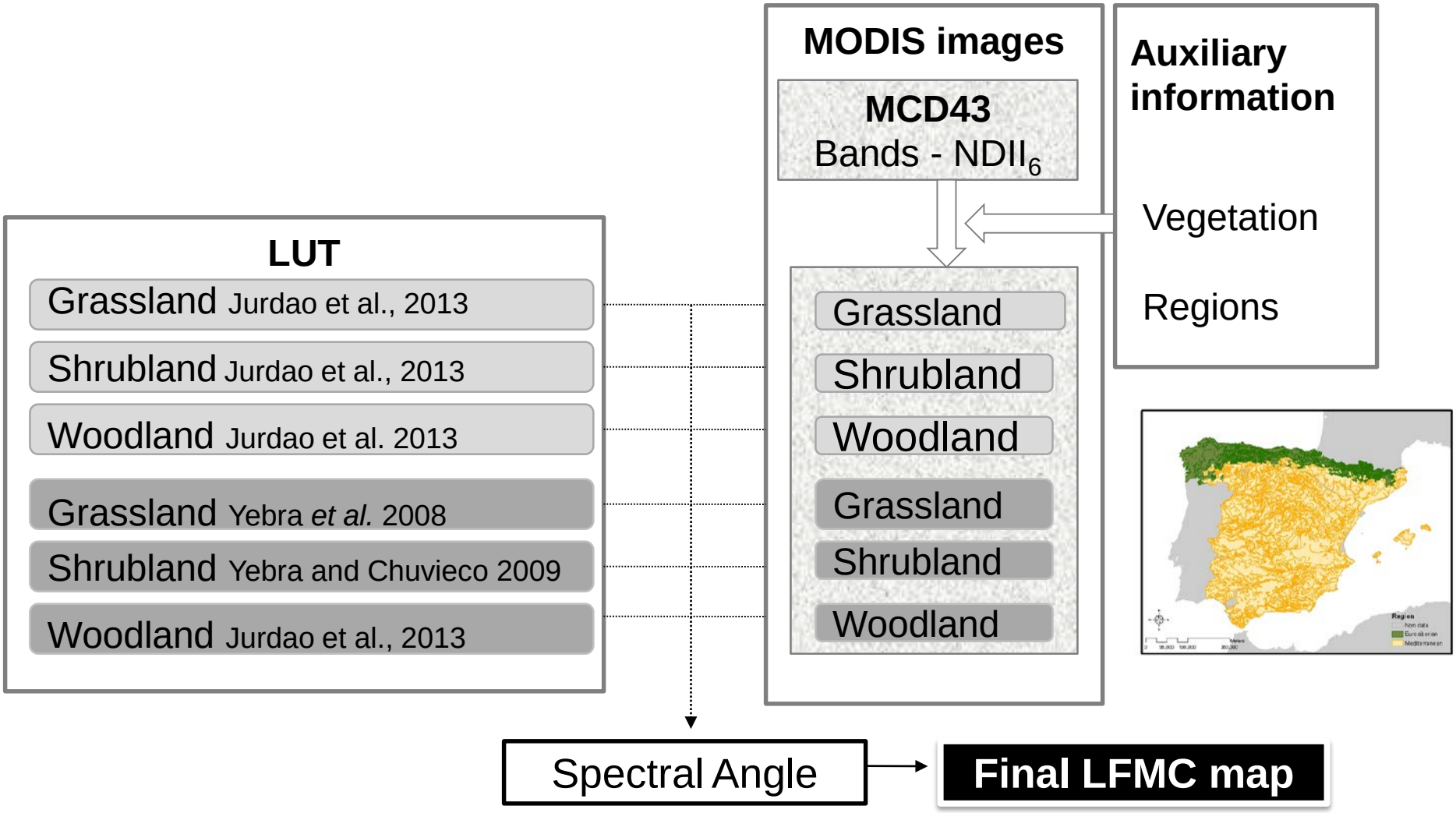
Fireglobe project
Chuvieco et al., 2014, IJWF

Fire risk = Danger * Vulnerability

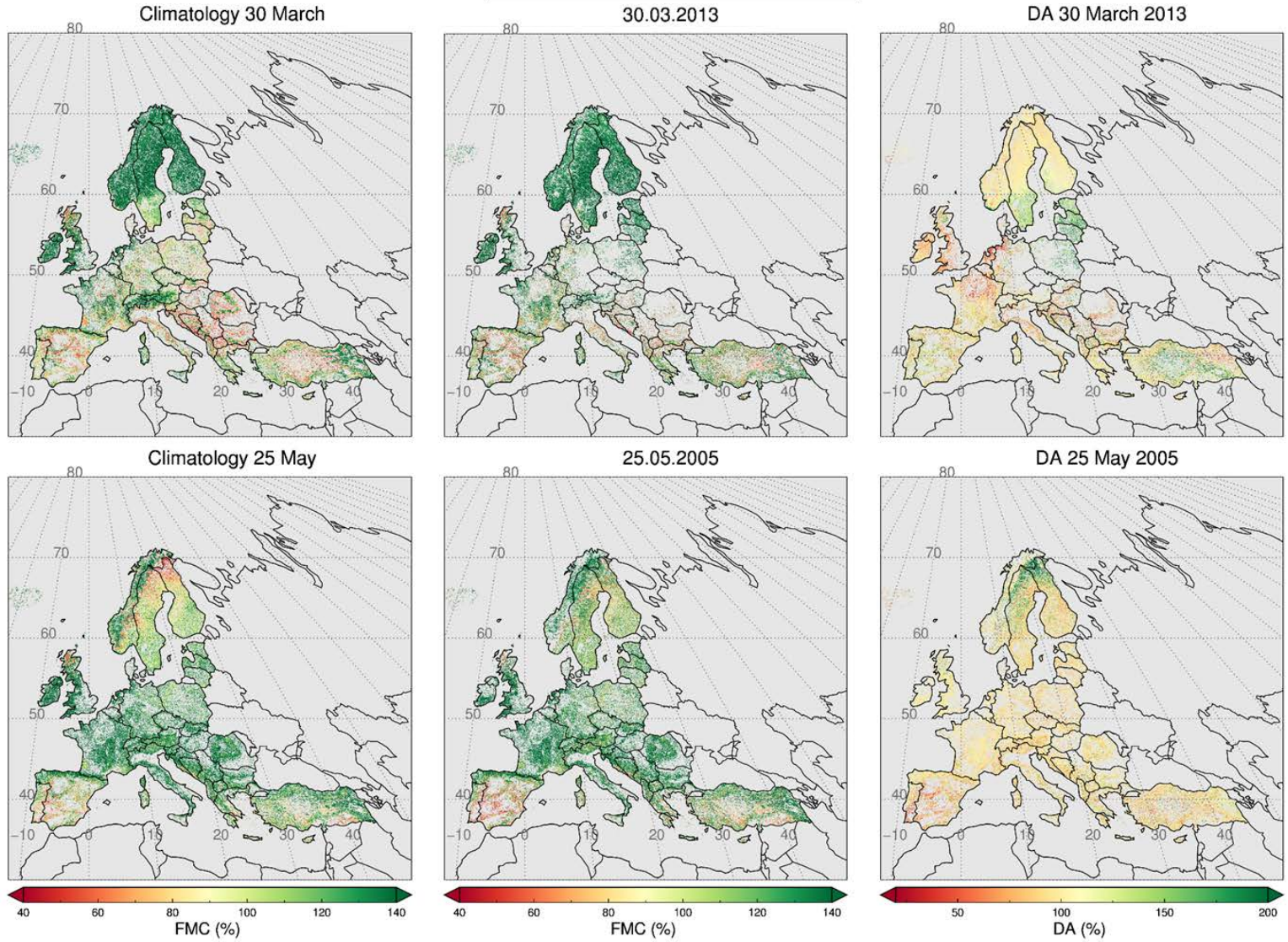


Fireglobe project
Chuvieco et al., 2014, IJWF

Semi-operational LFMC estimation

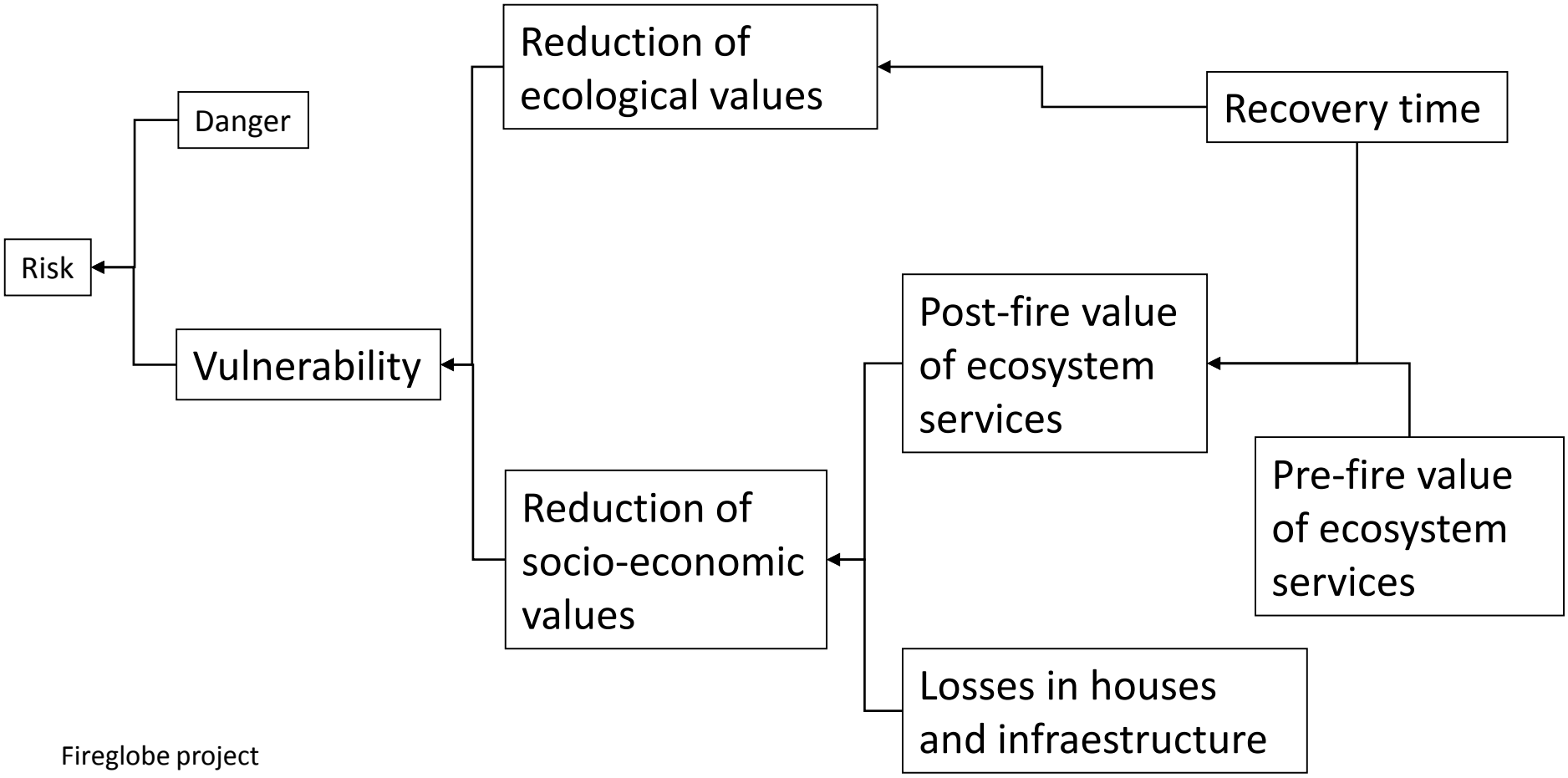


LFMC estimation from MODIS RTM modelling



Yebra et al., 2016

Fire risk = Danger * Vulnerability



Fireglobe project
Chuvieco et al., 2014, IJWF

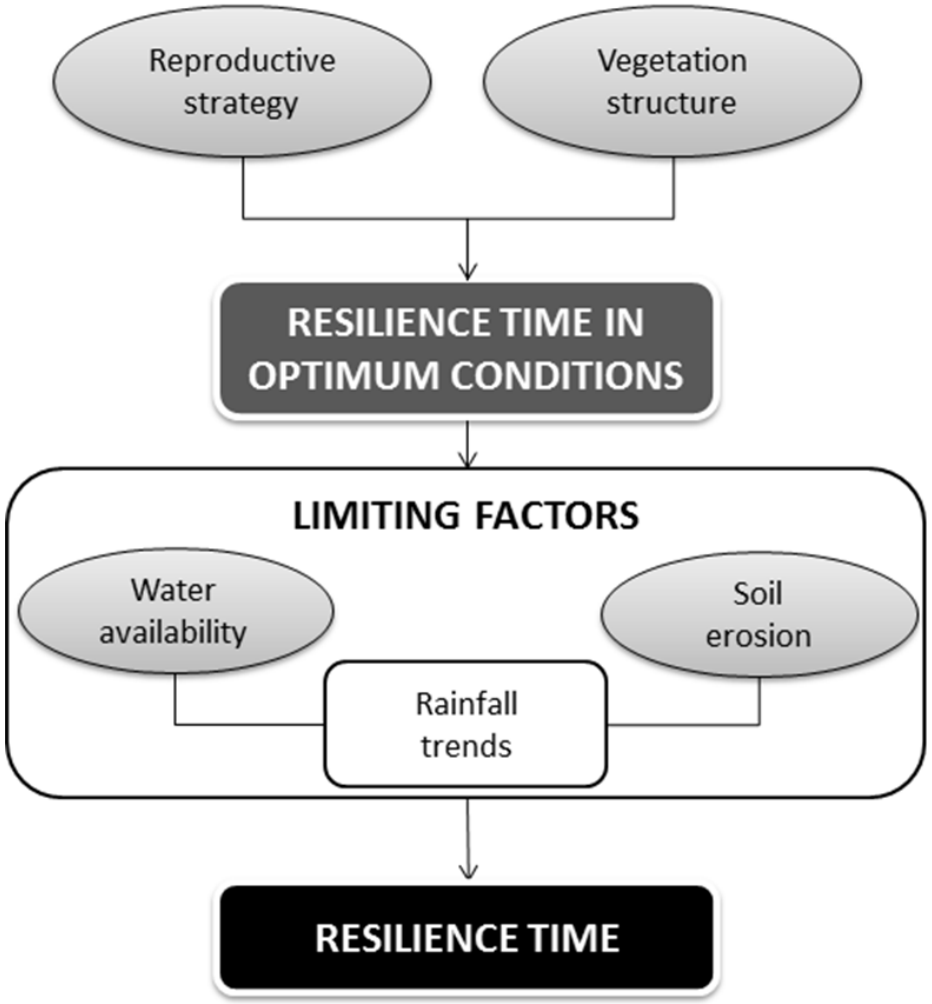
Present Marginal Loss (PML)

$$PML = ML * \frac{1 - (1 + r)^{-\log n}}{r}$$

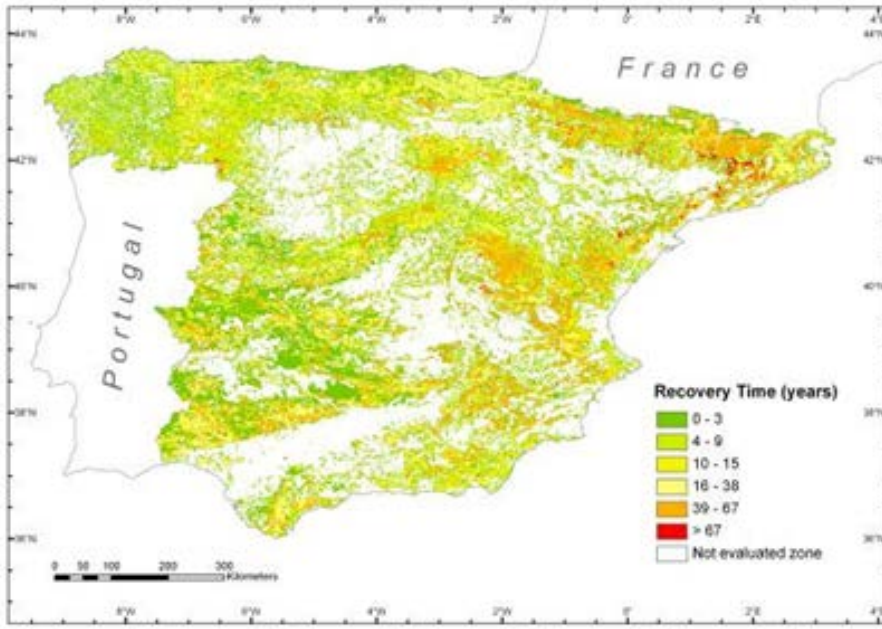
- ML = $V_1 - V_0$
- V_0 = Initial value of resource, related to economic assessment
- V_1 = Value after fire, related to fire behavior.
- **n: number of years to regenerate, related to ecological conditions and fire behavior.**
- r: Discount rate (2%).

Assumed
Estimated

Recovery time (n)



Rodrigues et al., 2014, PPG

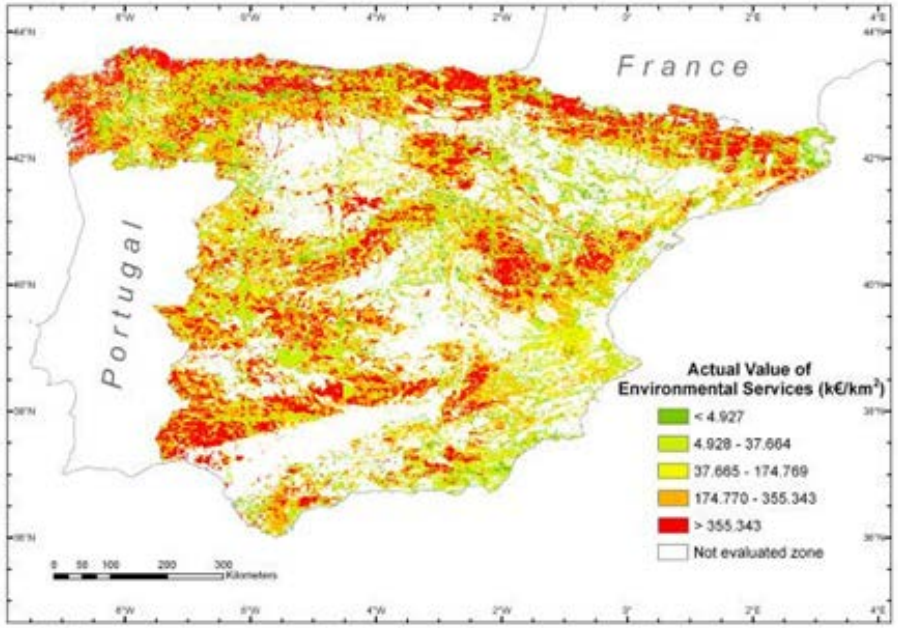


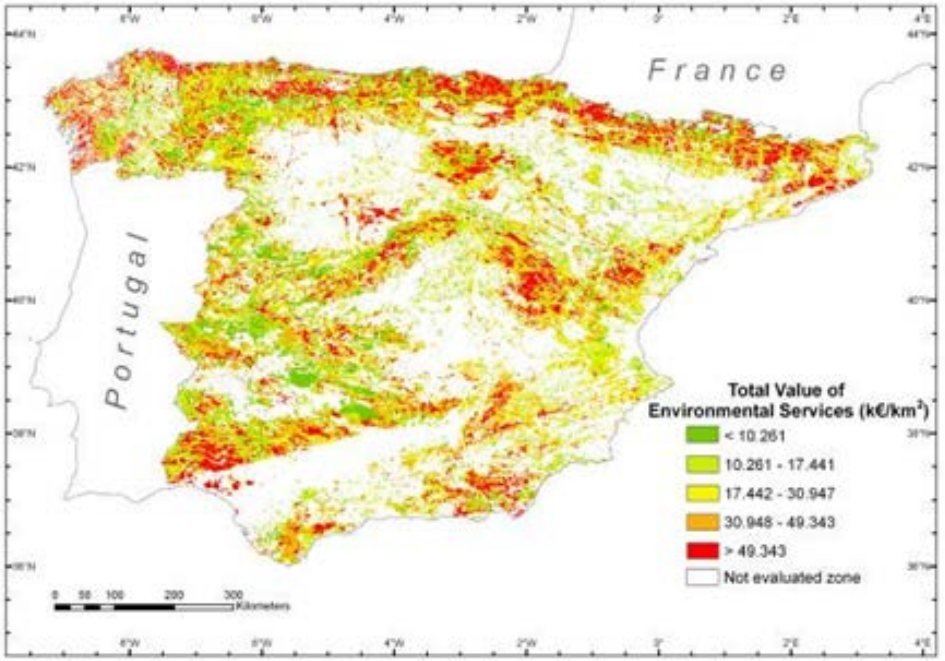
Chuvieco et al., 2014, IJWF

Ecosystem services

- Recreation.
- Wood / Firewood resources.
- Livestock and agriculture.
- Non-wood resources: Hunting, Fungi, Pine, Nuts, Cork, etc.
- Biodiversity.
- Water resources.
- Carbon markets.

Ecosystem services





Roman and Azqueta, 2012

Global fire vulnerability

Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2014) **23**, 245–258

RESEARCH PAPER

Integration of ecological and socio-economic factors to assess global vulnerability to wildfire

Emilio Chuvieco[1]*, Susana Martínez[2], María Victoria Román[3], Stijn Hantson[1] and M. Lucrecia Pettinari[1]

[1]*Environmental Remote Sensing Research Group, Department of Geography and Geology, Universidad de Alcalá, Colegios 2, 28801 Alcalá de Henares, Spain,* [2]*GI-TB Lab. Botánica y Biogeografía, IBADER, Campus de Lugo, Universidad de Santiago de Compostela, 27002 Lugo, Spain,* [3]*Department of Economics, Universidad de Alcalá. Colegios 2, 28801 Alcalá de Henares, Spain*

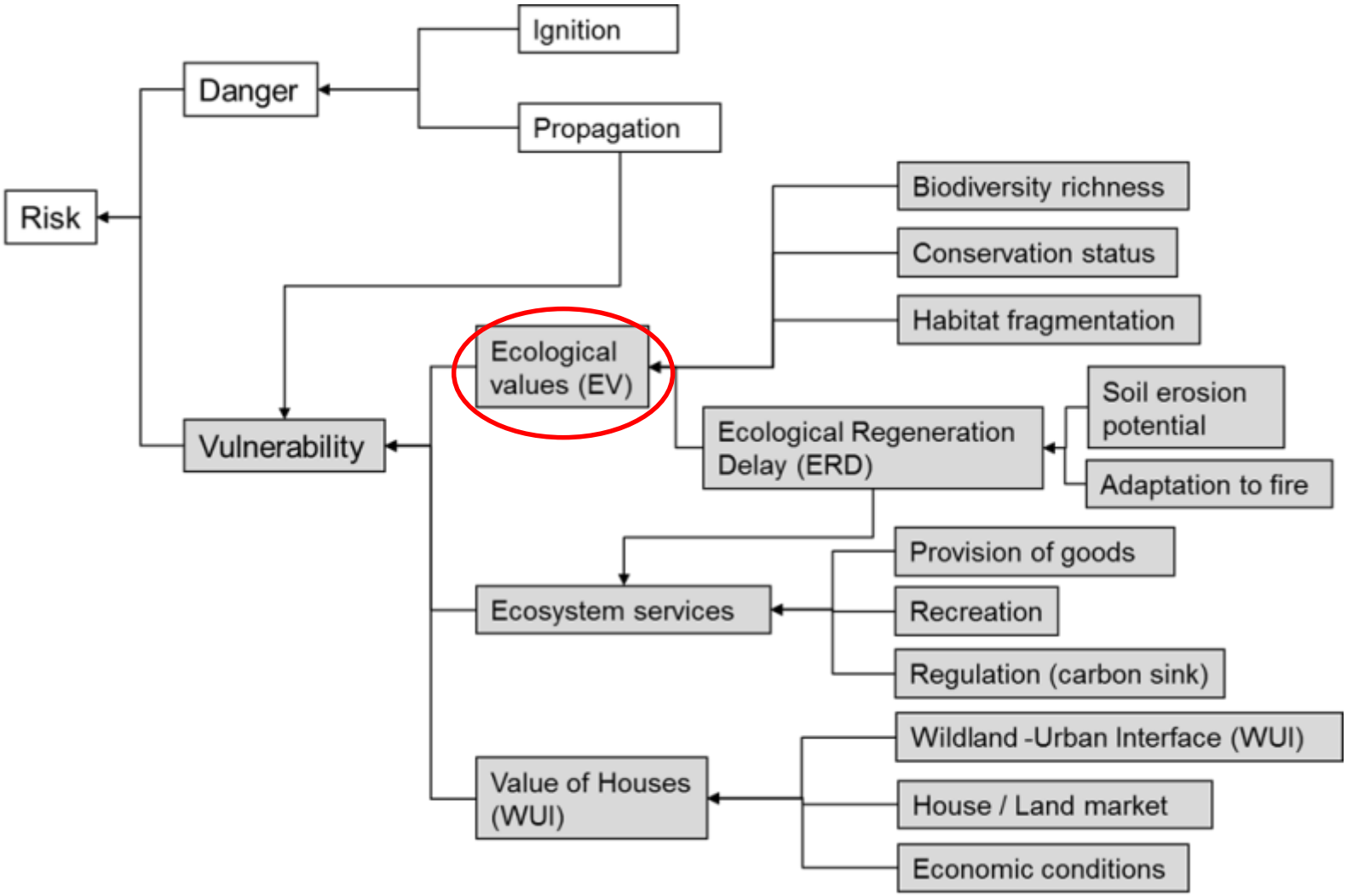
ABSTRACT

Aim This paper presents a map of global fire vulnerability, estimating the potential damage of wildland fires to global ecosystems.

Location Global scale at 0.5° grid resolution.

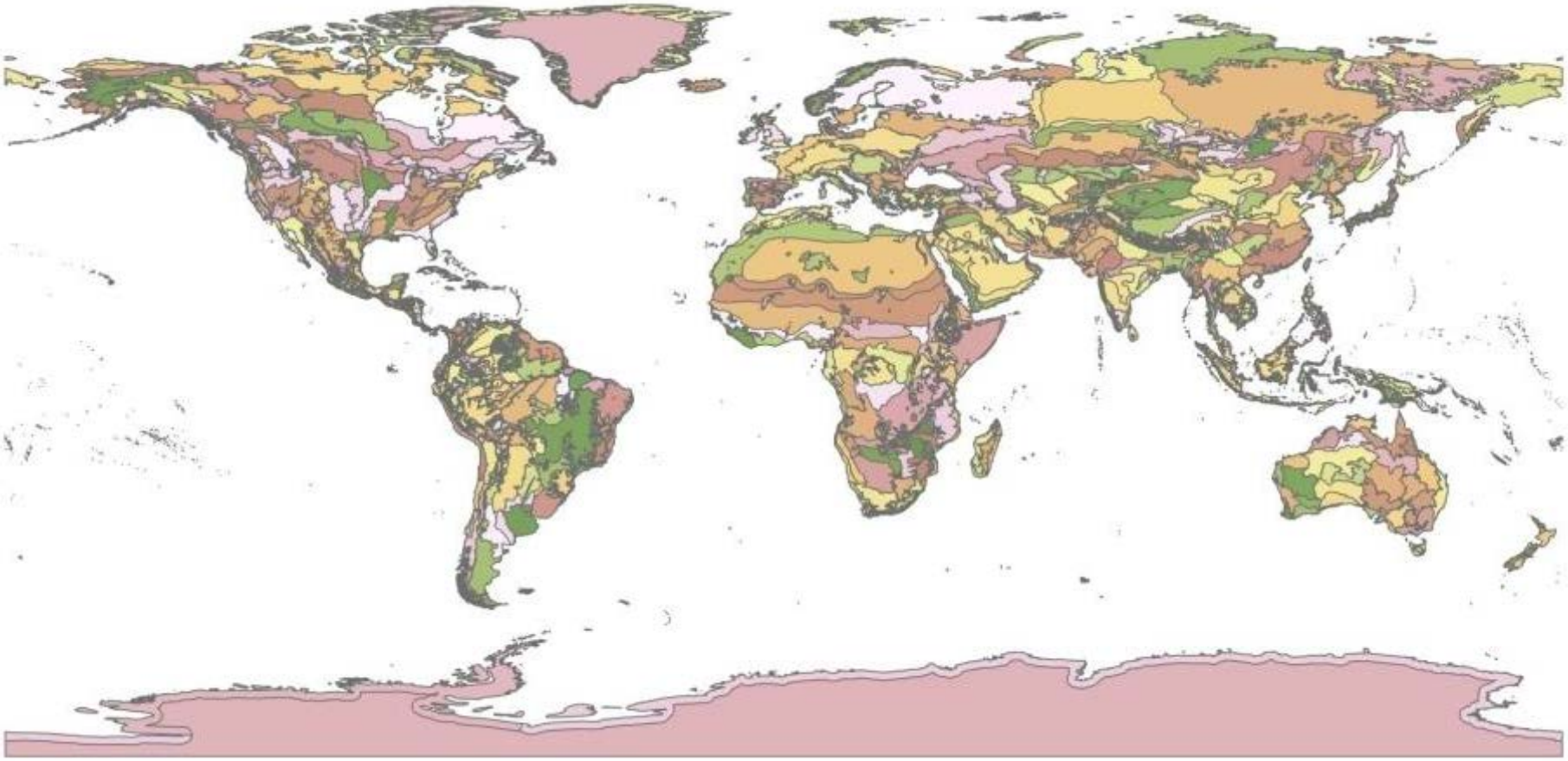
Methods Three vulnerability factors were considered: ecological richness and fragility, provision of ecosystem services and value of houses in the wildland–urban interface. Each of these factors was estimated from existing global databases. Ecological values were estimated from biodiversity relevance, conservation status and fragmentation based on Olson's ecoregions. The ecological regeneration delay was estimated from adaptation to fires and soil erosion potential. The former was assessed by comparing actual land cover with fire-off simulations based on a dynamic global vegetation model (ORCHIDEE). The annual loss of ecosystem

Global fire vulnerability



Chuvieco et al, GEB, 2014

Spatial units: ecoregions



825 tipified Terrestrial Ecoregions

Source: Olson et al., 2001

Biodiversity richness

- Strict endemics (END)
  - Σ amphibians, reptiles, mammals and avian in that ecoregion.
- Total richness (TR):
  - Σ amphibians, reptiles, mammals and avian in that ecoregion
- Average primary productivity (NPP).

Biodiversity richness (Ecoregion)

VARIABLE NAME	VARIABLE RANGE (inside every ecoregion)	Assigned values
END	0-97 (units: nº species)	Values between 1 to 4 following natural breaks
TR	0-1413 (units: nº species)	
NPP	0-1047900 (gr C)	

Conservation status

- Conservation status:
  - Σ (PAC, PA, IFL)
- Priority areas for global conservation (PAC) (Global200 + Hot-spots of biodiversity: Myers et al. 2000)
- Degree of protection (PA): world database of protected areas from the UNEP.
- Intactness (IFL) (Potapov et al. (2008).

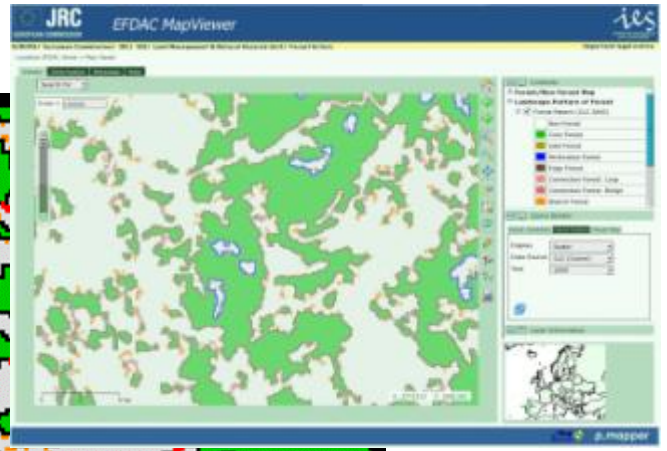
Habitat fragmentation

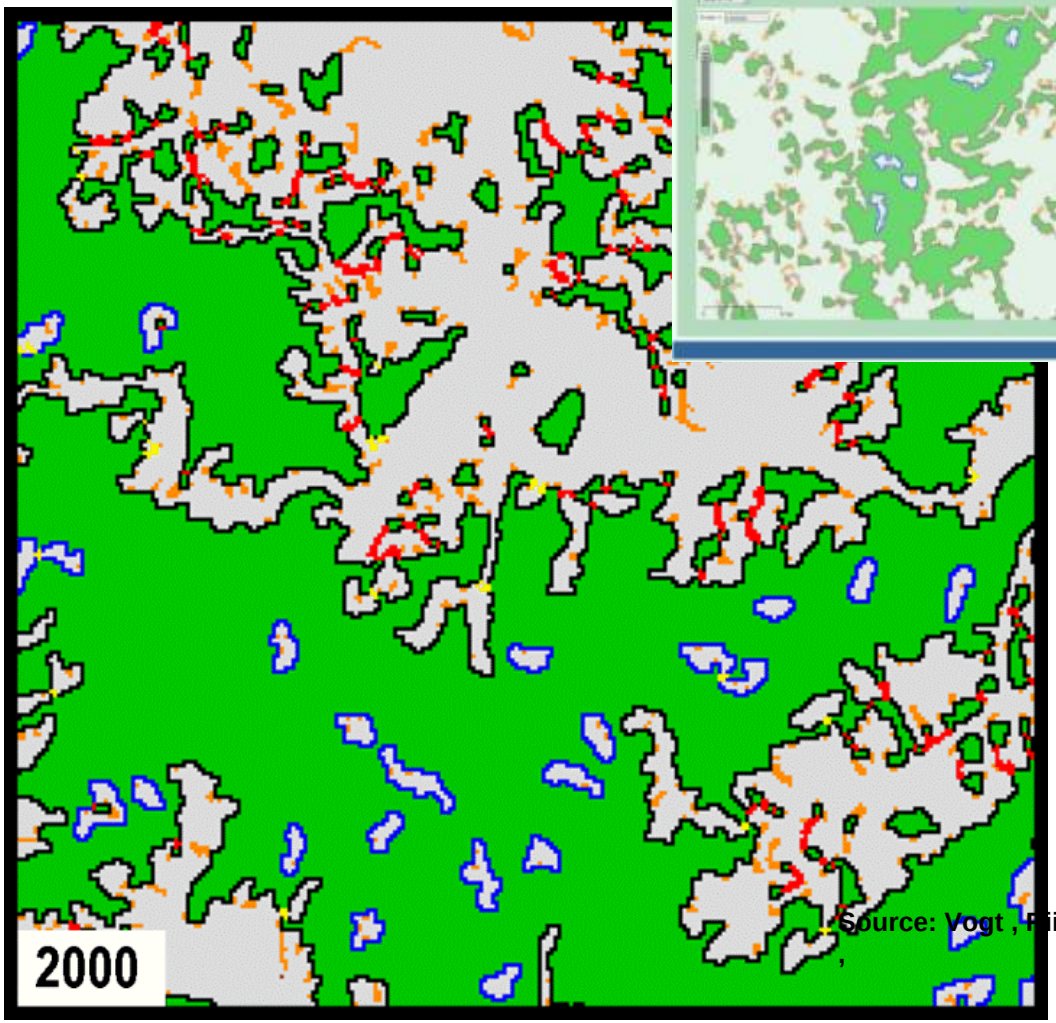
Global patterns of forest fragmentation

- Core
- Edge
- Perforation
- Bridge
- Loop
- Branch
- Islet
- Background
- No data

Fragmentation categories

GUIDOS software, JRC





Source: Vogt , Riitters, et al. 2007
,

Habitat fragmentation

MSPA categories	Definition	w_j
Core	Pixels within the forest matrix	2
Bridge	Pixels joining two forest patches	1.5
Perforation	Borders of non-forest islands within the forest matrix	1.3
Edge	Borders of the forest matrix	1.3
Loop	Pixels joining the same forest patch	1.2
Branch	Forest corridor linked to a forest patch	1.2
Islet	Forest islands outside the forest matrix	1.1
Background	Non-forested areas	1

Ecological Regeneration Delay

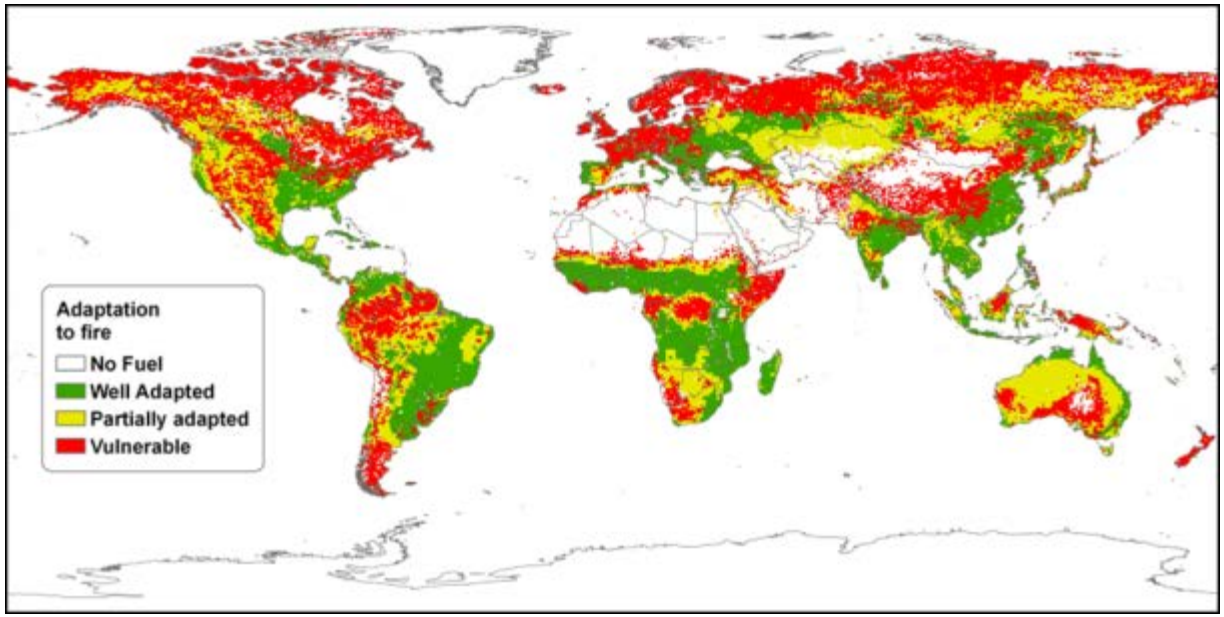
- Soil Erosion Potencial:
  - Soils.
  - Topography.
  - Rainfall
- Fire adaptation:
  - Potential vegetation (Orchidee)
  - Actual vegetation (Globcover2005).
  - Fire frequency (MODIS Hotspots).

Soil Erosion Potential

Slope factor	Level of protection	Soil erodibility & Rainfall erosivity factor		
		Low	Moderate	High
Very gentle	Fully protected	Low	Moderate	Moderate
Gentle	Fully protected	Low	Moderate	Moderate
Steep	Fully protected	Moderate	Moderate	High
Very steep	Fully protected	Moderate	High	High
Very gentle	Not-fully protected	Low	Moderate	Moderate
Gentle	Not-fully protected	Moderate	Moderate	High
Steep	Not-fully protected	Moderate	High	High
Very steep	Not-fully protected	Moderate	High	High

Fire adaptation

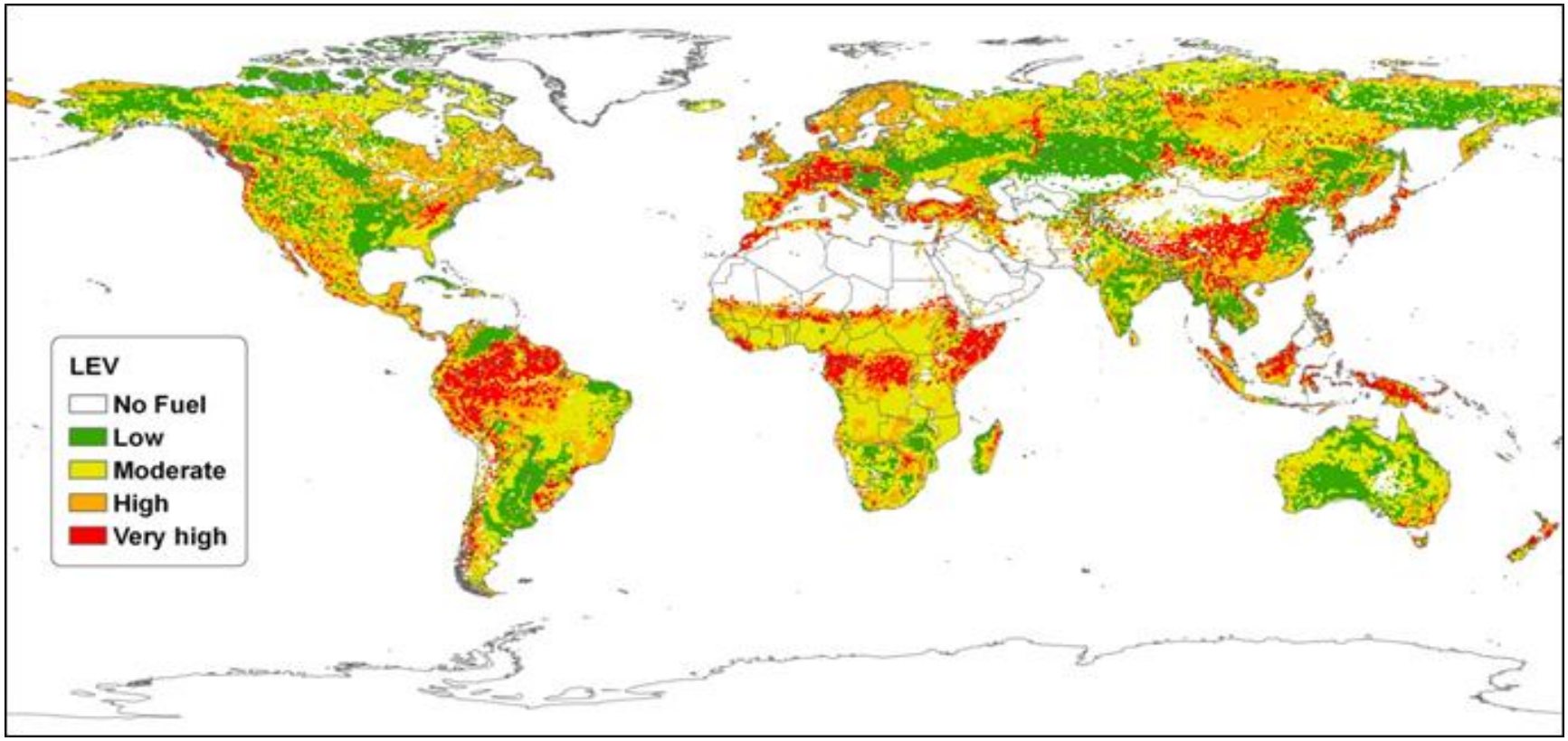
- Vegetated regions (density >60%):
  - If current vegetation cover ≈ simulated:
    - Low fire occurrence = Fire independent: highly vulnerable.
    - High fire activity = Partially adapted
  - If current vegetation cover ≠ simulated, fire dependent ecosystems.



Loss of Ecological Values (LEV)

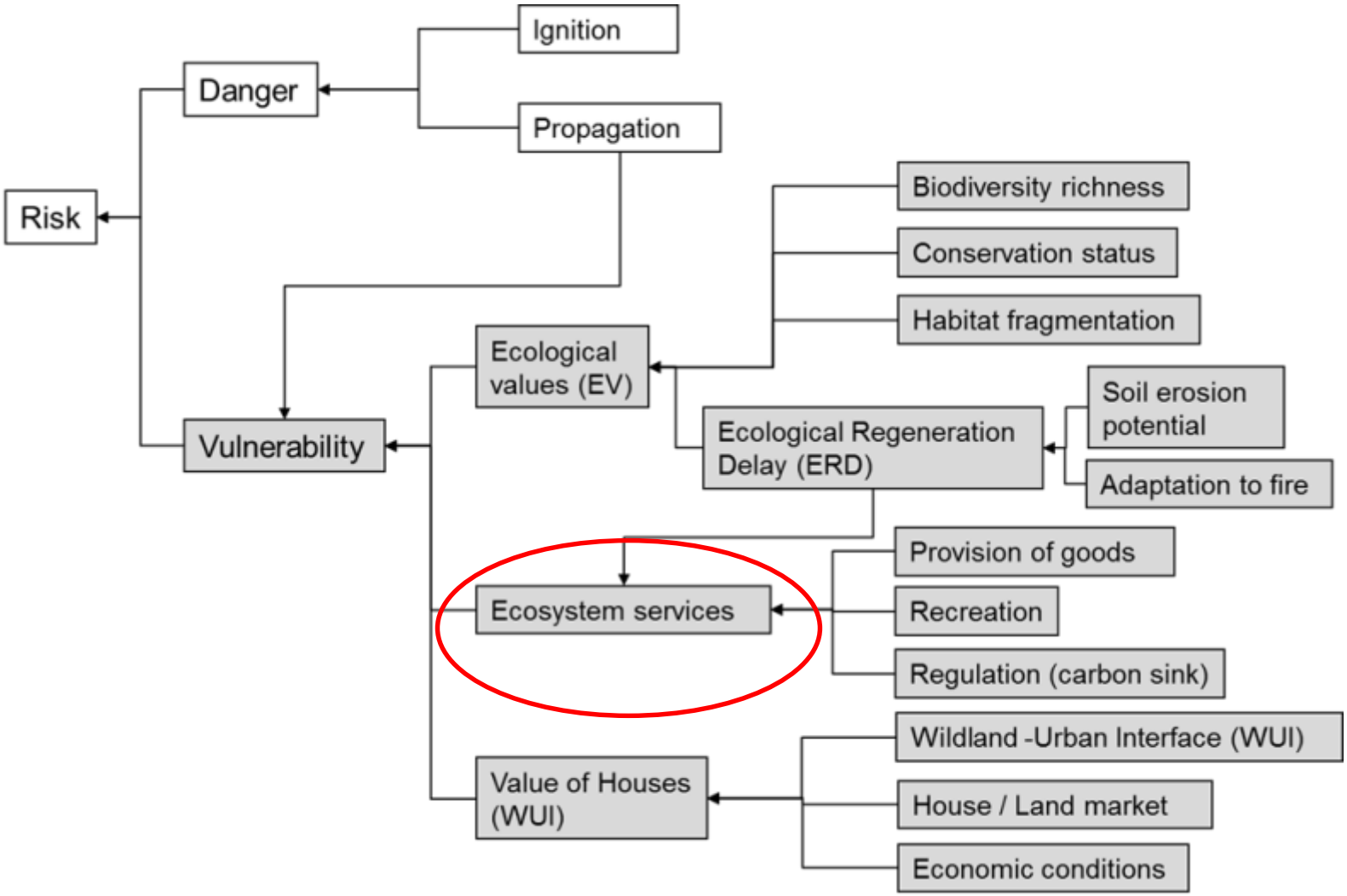
Ecological values	Ecological Regeneration Delay			
	Low	Moderate	High	Very High
Low	Low	Low	Moderate	High
Moderate	Low	Moderate	High	Very high
High	Moderate	High	Very high	Very high

Loss of Ecological Values



Chuvieco et al., 2014, GEB

Analysis of global fire vulnerability



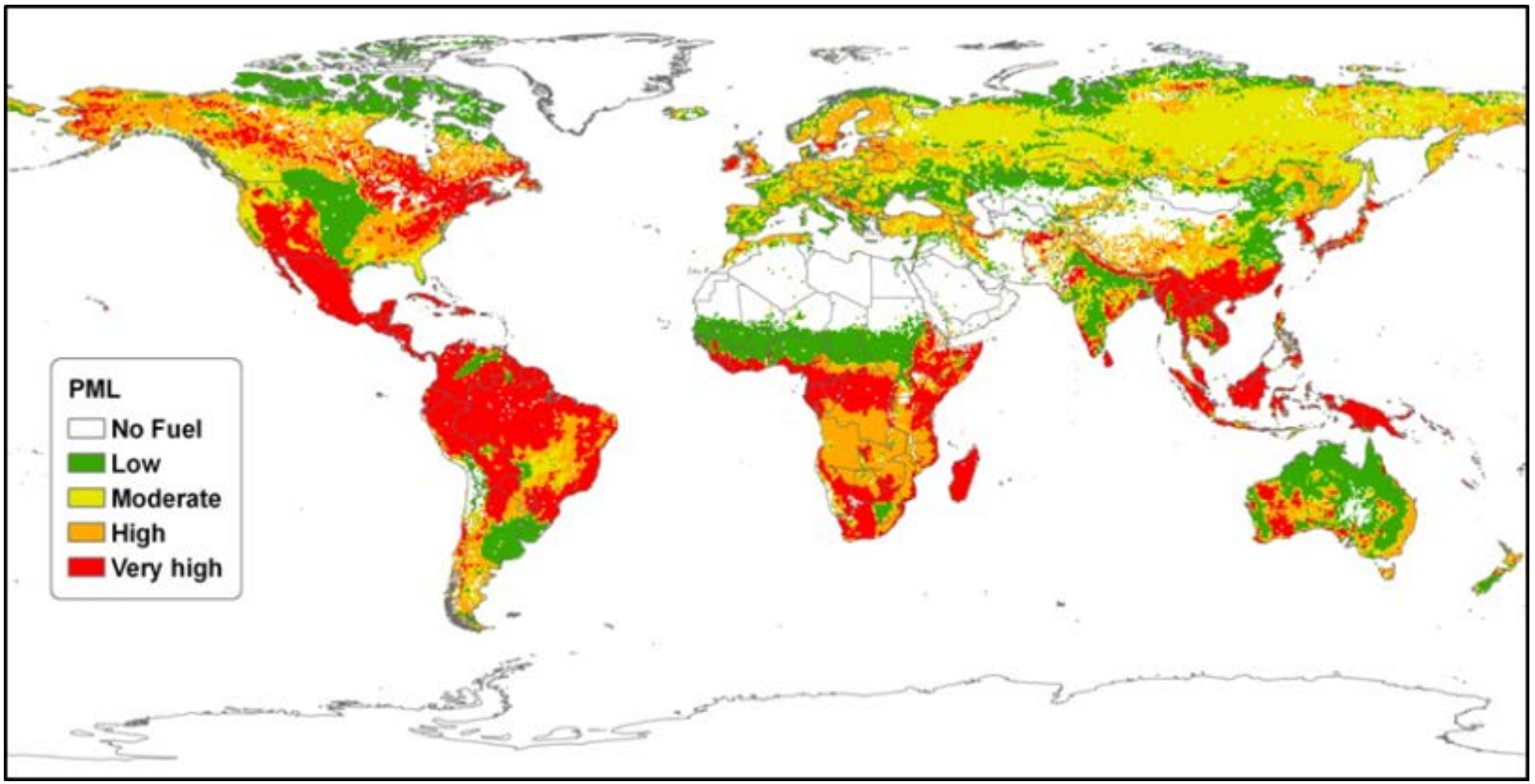
Chuvieco et al, GEB, in press

Present Marginal loss (PML)

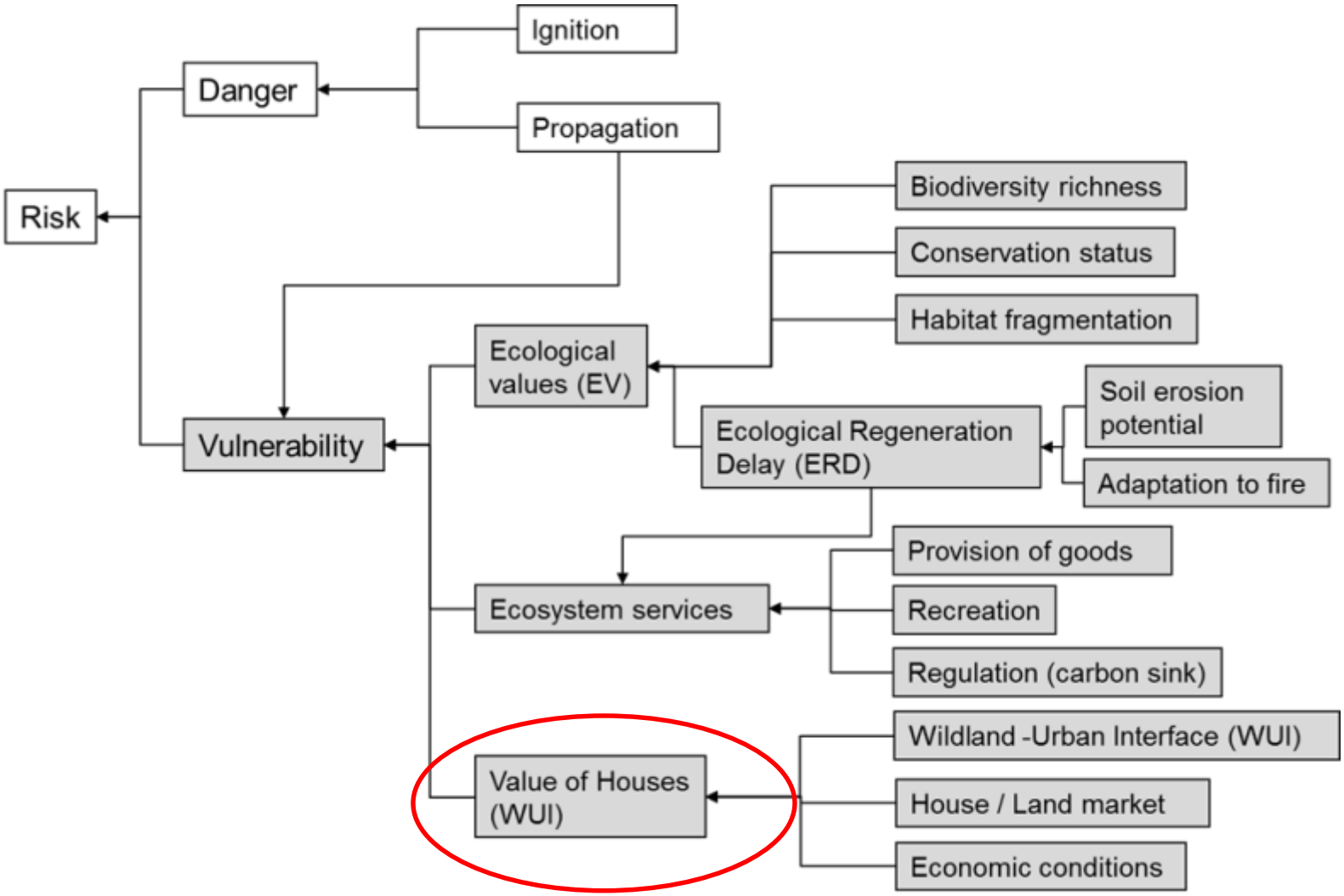
$$PML = ML * \frac{1-(1\mp r)^{-\log n}}{r}$$

- Favorable conditions:
  - n = 20 for forest,
  - n= 5 for shrublands
- Other conditions:
  - 1.2 * FC for moderate ERD
  - 1.4 * FC for low ERD
  - 1.5 * FC for very low ERD.

Present Marginal loss (PML)



Analysis of global fire vulnerability



Chuvieco et al, GEB, in press

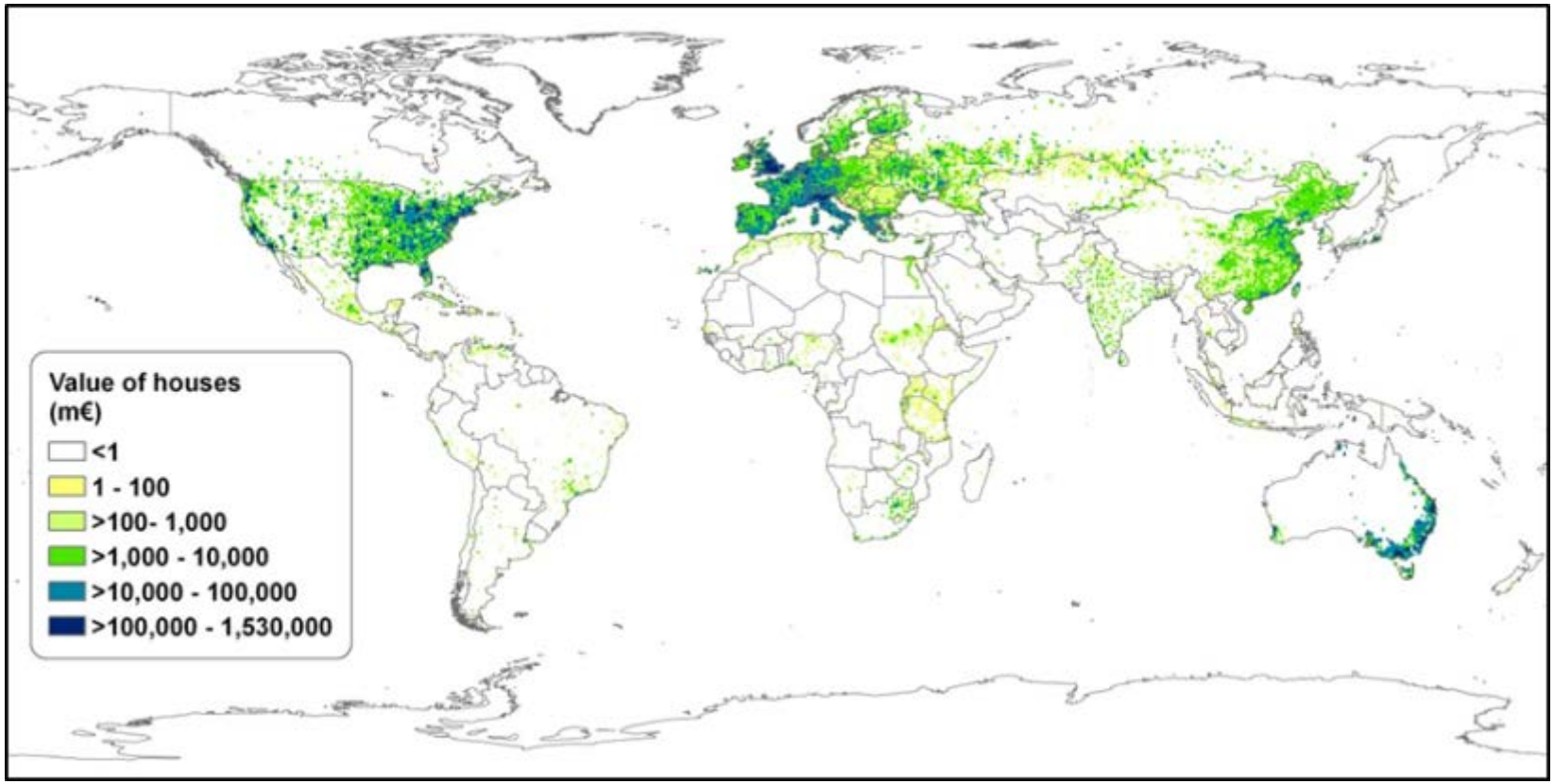
Value of houses

$$LH = \left(\sum_{i=1}^{n}(ML_i \times WUI_i \times BD)\right) \times d$$

- n is the number of different countries in each cell;
- MLi is the marginal loss by country I
- WUIi is the area of the WUI corresponding to each county in each cell;
- BD is the Built Density, an estimation of the proportion of built area within a cell. This value was fixed to 0.3, following CORINE
- d is a correction factor corresponding to population density of the cell.

Population Density Ranges (persons/km^2)	Correction factor (d)
➢0 – 10	0.6
10 – 100	0.7
100 – 500	0.8
500 – 1000	0.9
> 1000	1

Value of houses



Final vulnerability

Ecological Values	Socio-economic values			
	Low	Moderate	High	Very High
Low	Low	Moderate	Moderate	High
Moderate	Moderate	High	High	High
High	Moderate	High	Very High	Very High
Very High	High	High	Very High	Very High

Final vulnerability